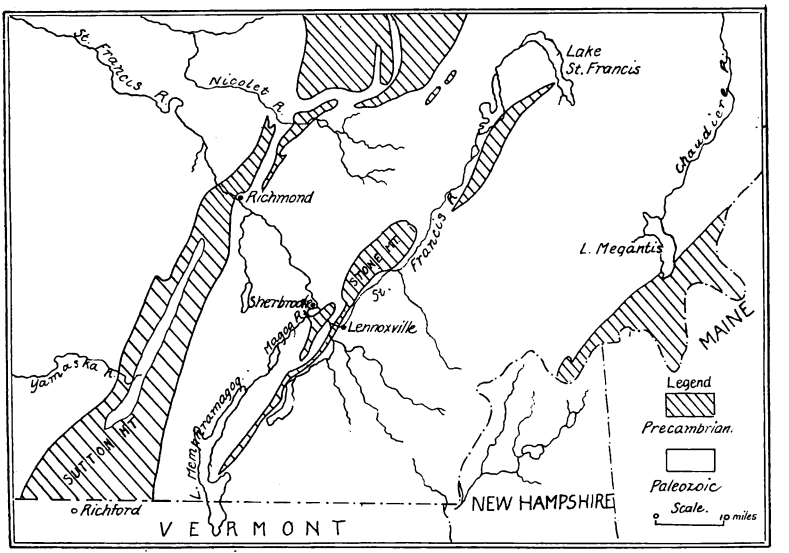
ART. X.—*A Petrographical Contribution to the Geology of the Eastern Townships of the Province of Quebec;* by JOHN A. DRESSER.

THAT portion of the Province of Quebec which lies south of the St. Lawrence River comprises two physiographically distinct regions, viz.: The flat country of the St. Lawrence valley, and that part of the Appalachian mountain system which belongs to this province. The part of the latter which occupies the Gaspé peninsula is known as the Shickshock mountains,



A Part of the Eastern Townships of the Province of Quebec.

and that between the vicinity of Quebec city and the United States boundary line as the Notre Dame Hills. The district lying within the Notre Dame hills is commonly designated as the "Eastern Townships," the geological structure of which has furnished the theme of much well-known discussion during the past forty years. This has been chiefly connected with the question of the Quebec Group.*

* "Geology of Canada," 1863, pp. 225-297, by Sir W. E. Logan.
"The Quebec Group in Geology," Transactions of the Royal Society of Canada, vol. I, 1882, by A. R. C. Selwyn.
"Notes on the Microscopic Structure of Some Rocks of the Quebec Group." Ann. Rept. Geological Survey of Canada, for 1880-1-2, by F. W. Adams.
"The Quebec Group." Appendix A to Harrington's Life of Sir W. E. Logan, by Sir J. W. Dawson, 1883.
Reports of the Geological Survey of Canada for the years 1886, J; 1887-8, K; 1894, J, by R. W. Ells.

As originally defined by Logan and Billings, the Quebec Group embraced all the rocks of the Eastern Townships that are essential to the present investigation, and all were then regarded as of sedimentary origin. Subsequently, however, Hunt, on stratigraphical grounds, and Selwyn on stratigraphical and lithological evidences, distinguished certain older measures, which were referred by the latter to the early Cambrian and pre-Cambrian ages. The amplification of the views has been fully carried out by Ells in the reports of the geological survey of Canada for the years 1886 and 1894.

The only lithological changes embodied in these reports are in the recognition of the eruptive origin of the serpentines and the diorites, diabases, porphyrites and granites generally associated with them. These had been previously regarded as metamorphosed sediments. The silicates of magnesia were correlated with its carbonates, where dolomite occurred in the vicinity of the serpentine belt, and even in 1886, Dr. Selwyn, who had been the first to recognize the igneous origin of the serpentines, in a footnote appended to Dr. Ell's report, maintains that the hornblende granites are probably products of metamorphism in situ and not true intrusives through the serpentine, as the latter writer correctly considers them to be.

In respect to age, the serpentines and certain of the clastics were referred to the early Cambrian and the other eruptions to middle or late Silurian time, while three belts of supposed sedimentary rocks, running approximately parallel to the northeasterly trend of the Appalachians were classed as pre-Cambrian. One of these appears for only a relatively short distance along the boundary line between the province of Quebec and the State of Maine. The second crosses the St. Francis river between the city of Sherbrooke and the village of Lennoxville. This may be known as the Ascot or Stoke Mountain belt, while the third, which crosses the St. Francis river a little way north of the town of Richmond, twenty-five miles northwest of the second, is generally designated as the Sutton Mountain belt. The structure of these bands, especially of the last mentioned, was long a crucial point in the Quebec group controversy, they being interpreted as synclines by the earlier investigators, and as anticlines by the latter.

PETROGRAPHY.—Recent petrographical investigations by the writer have, however, shown that both the second and third of these pre-Cambrian belts consist largely, and in places entirely, of altered volcanic rocks. These are so highly altered and consequently so much disguised, that they have

been hitherto mistaken for sedimentaries, and have been accordingly treated on that assumption in all the stratigraphical discussions regarding them.

(a) In the *Stoke Mountain belt* the principal rocks examined were taken from the township of Ascot, on the west side of the St. Francis river, between Sherbrooke and Lennoxville. Others were taken from various points to the southeastward on the upper Belvidere road and from the vicinity of the Suffield, Sherbrooke and Clark copper mines. The rocks, which are generally fine in texture, are of various shades of green and gray in color, and many are in advanced stages of metamorphism. In the thin section, however, the microstructure remains sufficiently distinct to clearly establish the igneous origin of practically all of these rocks, and even to identify the specific characters of several on the merely preliminary examination of them that has yet been made.

Quartz-porphyry forms the hanging wall of the Silver Star mine at Suffield. It is of light gray in color, and from the prominence given the quartz phenocrysts by the bleaching of the base of the rock on weathered surfaces, it has been commonly regarded as a species of sandstone.

By the aid of the microscope the structure is found to be that typical of an effusive rock. A very finely crystalline base holds phenocrysts of quartz, which show in basal sections an uniaxial cross and positive sign ; and also of feldspar, which extinguished in several cases with its principal axes parallel to the planes of the crossed nicols and hence is orthoclase. A few feldspars are polysynthetically twinned and accordingly are plagioclase. Their extinction angles are small. Small rod-like individuals of colorless mica arranged in lines are presumably of secondary origin. They often occur within, or in association with, irregular areas of a rhombohedral carbonate, apparently dolomite.

Granite-porphyry occurs near Lennoxville on the line of the Canadian Pacific Railway. It differs from the quartz-porphyry chiefly in the more advanced character of its crystallization, both quartz and feldspar being distinguishable in the groundmass. A little chlorite, pyrite, brown iron oxide, and colorless mica are also present. An incipient cataclastic structure is beautifully shown in both of these rocks. The quartz-phenocrysts are sometimes reduced to mosaics of quartz grains, or at others are crossed by lines of crushed material, while the crystals on either side of the lines remain unchanged or show undulatory extinction. Being the largest single masses and of the most brittle material, the quartzes thus appear in every case to be the first constituents to show the effects of purely dynamic metamorphism. A much altered rock form-

ing the hanging wall of the Clark mine was probably closely allied to the quartz-porphyry in its original composition. It rather closely resembles a specimen of "sheared felsite" from the Gettysburg Railway, south of Clermont House, Monterey, Pennsylvania, seen in the petrographical collection of McGill University.*

A greenish gray fine-textured massive rock is of large extent, especially in the southern part of this belt. In the thin section quartz is found in broken phenocrysts and also in smaller grains, presumably primary, in the rather fine holocrystalline groundmass. Under high power (x220) feldspar appears in the groundmass in small lath-shaped individuals which extinguish at low angles with the principal axes. Epidote and chlorite are abundant representatives of primary bisilicates. The rock would have originally been about of the character of a quartz porphyrite.

A large part of the central and southern portions of this belt in the township of Ascot is occupied by a highly foliated rock of green color and massive appearance. Under the microscope a little feldspar is found in an aggregate of colorless hornblende, chlorite, epidote, dolomite and sericite, all of which are secondary constituents.

This rock agrees essentially with the sheared greenstone from Jack's Mountain tunnel, near Monterey, Pennsylvania, as seen in the McGill University collection.

A similar but more dolomitized rock occurs in various parts of the belt, one occurrence of which is mapped as igneous on the map to accompany the Annual Report of the Geological Survey of Canada for 1886.

These rocks, though probably of several different ages of eruption, are generally much metamorphosed. But cutting them there are dikes of camptonite and olivine diabase, which are quite undisturbed in position and comparatively little altered in mineralogical composition. They also cut the Lower Trenton strata along the edges of the belt, while these overlie the other igneous rocks of the region. Whence it appears that the Stoke Mountain, or Ascot belt, has been the scene of volcanic activity at various periods through a long range of time, from pre-Cambrian to post-Trenton. A brief notice of the lithological character of those rocks has been recently given by the writer in a communication upon the copper-bearing rocks of the area,† and their general agreement in extent with the pre-Cambrian of the Geological Survey Map of 1886 pointed out.

* Bulletin U. S. Geological Survey, No. 136, "Ancient Volcanic Rocks of South Mountain, Pennsylvania," by F. Bascom.

† Trans. Can. Min. Inst., Montreal, March, 1902.

(b) The igneous origin of a portion of the pre-Cambrian area, which forms the *Sutton Mountain belt*, was pointed out by the writer in a note to the Ottawa *Naturalist* of January, 1901. Since that time the extent of the igneous portion has been more fully examined, especially to the northeast of the St. Francis river, and its structural relations better ascertained. It is found to comprise the greater part of the pre-Cambrian of this area, as shown on the latest geological survey map of the region, that of 1886.

As far as examined, for a distance of some forty miles on either side of the St. Francis river the rock is an altered greenstone, very commonly amygdaloidal. In the microscopic section a little primary plagioclase sometimes remains, but in many sections the whole field consists of a secondary aggregate of chlorite, epidote, iron ore and leucoxene. The amygdules usually consist of quartz and zeolitic minerals. The rock is much foliated and has been generally described as a chloritic slate. Its resemblance to the basic rocks of the Ascot area is very close. It, too, is important as a copper-bearing rock.

In geographical position these volcanic belts form a link in the more westerly of the two chains of ancient volcanics designated by the late Prof. G. H. Williams,* while in their lithologic characters they agree with certain of the South Mountain rocks of Pennsylvania in all essential respects.† The Quebec rocks are, however, largely made up of the acid types, some of which agree essentially with rocks from Ascot. Most of the specimens are in less advanced stages of recrystallization than the rocks above described.

The basic phases from the Stoke Mountain area as well as those which comprise the Sutton Mountain belt are closely analogous to the greenstones from the vicinity of Monterey.

STRUCTURE.—As already stated, these rocks were formerly regarded as presenting synclinal structures, while the later investigators have believed them to form anticlines, the former view making them later in age than the adjacent rocks, the latter, earlier. With respect to relative age, the latter opinion is doubtless the correct one. The lowest sedimentary rock, dolomite, on the south side of Sutton Mountain belt in the township of Melbourne, for instance, contains fragments of the adjacent trap, and large areas of mica schists

* The Journal of Geology, Jan.-Feb., 1894.

† A collection of rocks from this locality, which is in the petrographical laboratory of McGill University, has been examined for comparison through the courtesy of Prof. F. D. Adams, to whom my best thanks are also offered for valuable aid and advice in several matters connected with this subject.

in the vicinity are made up of its débris. Other evidences also point to the later age of the sedimentary rocks, which generally belong to the Trenton formation, and none to the reverse relation. The change of view in regard to the origin of these rocks, from sedimentary to igneous, does not, therefore, necessarily alter the recent determinations either of their relative or of their actual geological age. It would, however, be well that the evidence on which the latter determination was made should be carefully reviewed in the light of the present knowledge of their volcanic character.

On the other hand, the elimination of these volcanics leaves the stratigraphical structure of the sedimentary rocks a much simpler one than has hitherto been supposed.

A detailed study of the Sutton belt and adjacent formations in the vicinity of the St. Francis river shows the sedimentary rocks of the Quebec Group to occupy a trough between the volcanic ridge on the north and the serpentine belt at the south. Both these have apparently been covered by sediments which are now in part removed by denudation.

A *summary* of the results of this study, therefore, shows:

1. That at least the greater part of the pre-Cambrian or crystalline belts of the eastern townships of Quebec is of igneous, not sedimentary origin, as has been hitherto supposed.

2. That these rocks are allied to the volcanics of South Mountain, Pennsylvania, especially to the basic types, and indicate the continuance of this class of rocks throughout the Appalachians, as was suggested by Williams.

3. That the sediments of the region, which probably all belong to the Quebec Group, were deposited between and upon the preëxisting ridges of igneous material, which are now being uncovered by denudation, while the intervening valleys still remain deeply filled.

The pre-Cambrian area near the international boundary line, before referred to, and also the extension of the Sutton belt into the State of Vermont, would furnish subjects of investigation of especial interest in connection with the areas herein described.

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